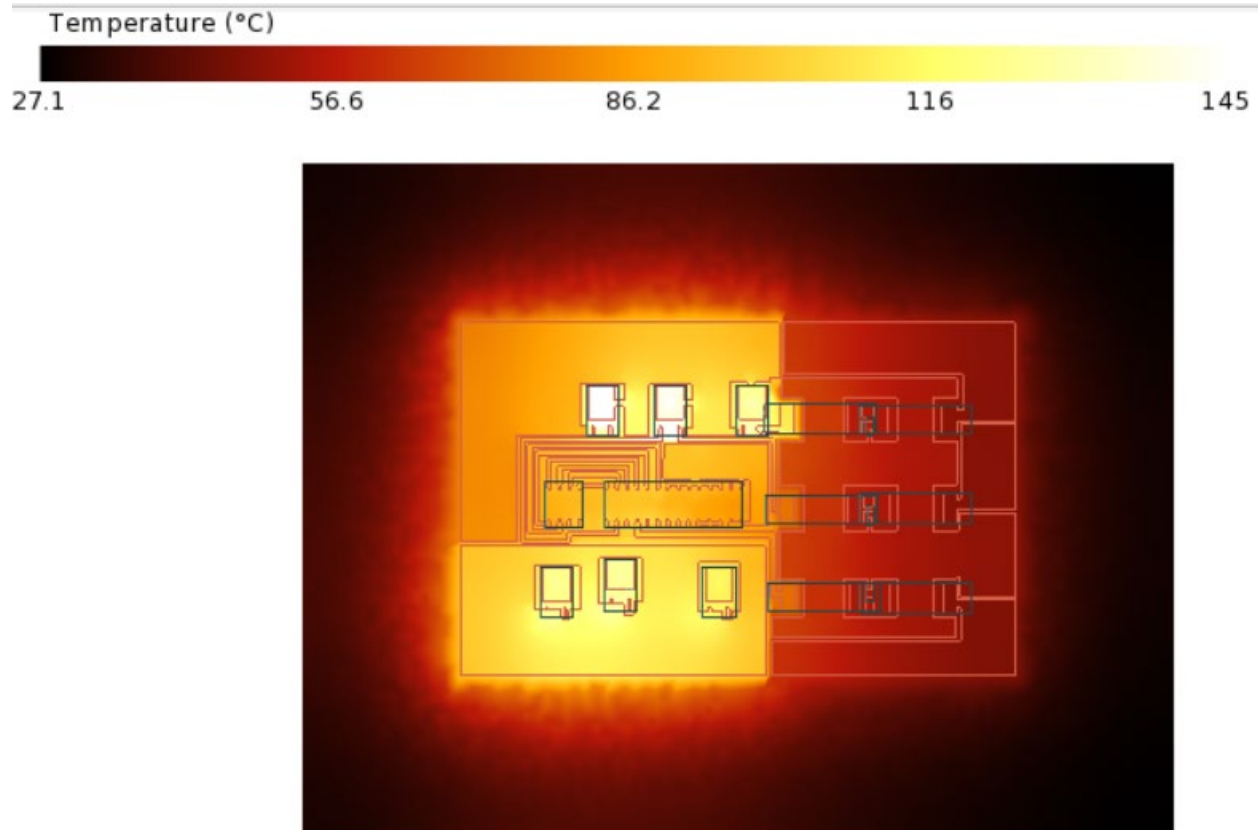


PEPro Thermal Analysis for Power Converter Design

Introduction



In power electronics design, effective thermal management stands as a cornerstone for ensuring the reliability, efficiency, and longevity of devices. The demand for high-performance power converters capable of handling increasingly higher power densities has never been greater. The importance of thermal considerations has been emphasized to unprecedented levels with the advent of wide bandgap semiconductor materials such as Silicon Carbide (SiC) and Gallium Nitride (GaN).

The emergence of SiC and GaN devices, with their superior electrical properties compared to traditional Silicon-based components, has revolutionized the landscape of power electronics. These wide bandgap materials offer higher breakdown voltages, lower on-state resistance, and faster switching speeds, enabling power converters to operate at higher frequencies and power levels. However, this enhanced performance comes at the cost of increased heat generation, making effective thermal management an absolute necessity.

The adoption of SiC and GaN devices has led to power converters operating at higher power densities and temperatures than ever before. Consequently, the thermal challenges faced by designers have become more complex and demanding. Failure to adequately address thermal issues can result in reduced efficiency, compromised reliability, and even catastrophic device failure.

In this application note, we delve into the intricacies of thermal analysis using the Keysight EDA W3631B Power Electronics Bundle. This simulation solution utilizing Advanced Design System (ADS) and Power Electronics Professional (PEPro), a sophisticated tool designed to assist engineers in navigating the thermal complexities of power electronics design. Through meticulous examination of thermal resistance ratings, graphical analysis, and comprehensive simulations, engineers can gain valuable insights into the thermal behavior of their designs.

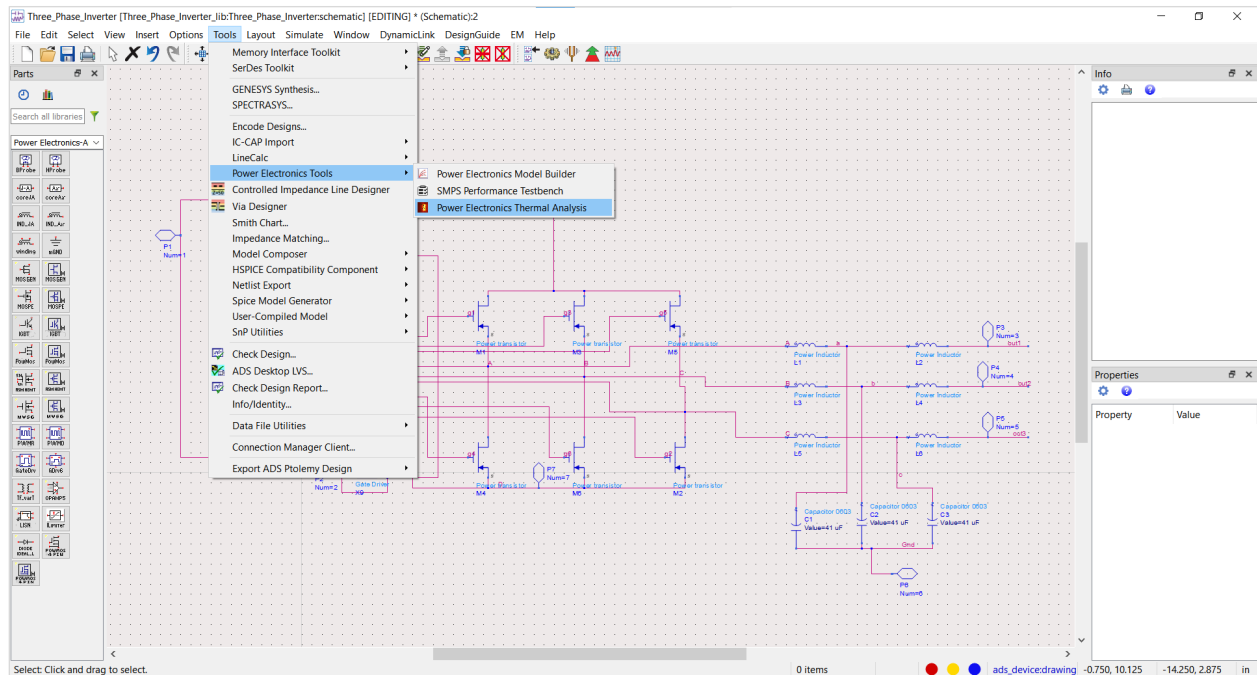


Figure 1. Schematic level thermal analysis

You initiate your thermal analysis at the schematic level while constructing your power converter. Within ADS, there exists a dedicated thermal analysis tool enabling the examination of specific power transistors intended for use in your design. By assessing the thermal impact of your chosen technology at this early stage of the workflow, you can identify potential issues before committing to a particular transistor or technology. During this phase, crucial information such as junction-to-case resistance and junction-to-ambient resistance can be gathered from the datasheet of the specific part under scrutiny in the circuit simulation. Upon completion of the thermal analysis, a table of calculations is generated, detailing power loss across your transistor device and the calculated junction temperature. This initial insight provides valuable understanding of the thermal performance of your circuit. Subsequently, you can export this information in CSV format, facilitating transition to the next stage of the workflow: board-level thermal analysis in PE Pro.

DC Results Overview - Thermal Analysis

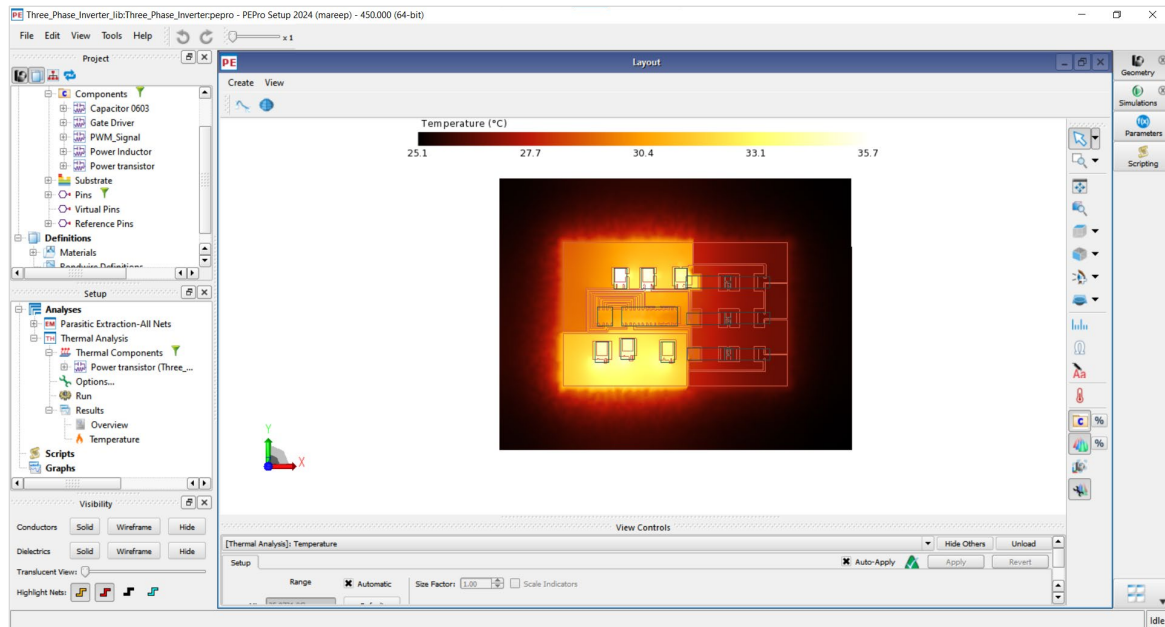
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Thermal Components Layers Pins Vias

Name	Source [W]	Heat To Board [W]	Heat To Case [W]	T [°C]	Board T [°C]	Junction T [°C]	Case T [°C]
M1	0.835	0.0783095	0.756691	---	36.8	41.5	40.1
M2	0.762	0.0952741	0.666726	---	33.8	39.5	38.3
M3	0.75	0.0679119	0.682088	---	35.8	39.9	38.6
M4	0.829	0.0996708	0.729329	---	34.9	40.9	39.6
M5	0.722	0.0725071	0.649493	---	34.8	39.2	38.0
M6	0.699	0.0676336	0.631366	---	34.7	38.8	37.6

Figure 2. Board level thermal analysis

Thermal source data is exported to a CSV file following schematic level analysis, which is then imported into PEPro to initialize thermal analysis. Here, power transistors are identified and equipped with thermal properties such as junction-to-case resistance and consideration for heatsink utilization, while factors like airflow, surrounding temperature, and heat transfer coefficients are configured. Leveraging a powerful thermal solver, PEPro accounts for the spatial arrangement of devices relative to one another and the composition of the printed circuit board, providing a more precise depiction of thermal effects. The subsequent thermal simulation yields results including heat maps and temperature tables. In post-layout analysis, power transistors are strategically positioned on the board to optimize heat dissipation and airflow, with adjustments made to thermal properties based on the actual layout, including parameters like junction-to-board resistance. Surrounding conditions are updated to accurately reflect real-world scenarios post-layout, and the thermal simulation is rerun to validate thermal performance under board-level conditions.



Conclusion

Thermal analysis in PE Pro offers a comprehensive solution for power electronics design, ensuring reliable operation under various conditions. By leveraging advanced tools and accurate simulations, engineers can streamline the design process, reduce costs, and bring products to market more efficiently. For a demonstration of PEPro's capabilities, please refer to the accompanying workspace demonstration.

W3631B Power Electronics Bundle

- Advanced Design System (ADS) Core
- EM Design
- Layout Tool
- W3026E PE Circuit Simulation (Schematic Thermal Feature)
- W3035E PEPro (Board Thermal Feature)

Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.



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